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Contribution from the Bureau of Animal Industry

JOHN R. MOHLER, Chief

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POISONOUS PROPERTIES OF THE WHORLED MILKWEEDS ASCLEPIAS PUMILA AND A. VERTICILLATA VAR. GEYERI.

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PURPOSE OF PAPER.

As stated in Department Bulletin 800, "The Whorled Milkweed (*Asclepias galioides*) as a Poisonous Plant" (pp. 5 and 6), there are certain other species of whorled milkweed closely related to *A. galioides*. These species have a fairly wide distribution in the United States and it is a matter of considerable interest to know whether they have poisonous properties similar to those found in *A. galioides*. While hitherto these other species have not been examined experimentally, there has been good reason to suspect some of them of being connected with losses of livestock.

Experimental work on two species, *A. pumila* and *A. verticillata* var. *geyeri*, has now demonstrated their toxic character, and also has brought out quite definitely the character of their action as compared with *A. galioides*. In this bulletin are summarized the results of the experimental work on these plants. The work accomplished indicates that *A. pumila* is about one-third as toxic as the very poisonous *A. galioides*, and *A. verticillata* var. *geyeri* is less poisonous, being about one-tenth as toxic as *A. galioides*.

DESCRIPTION OF ASCLEPIAS PUMILA.[1]

Asclepias pumila (Pl. I) may be called low whorled milkweed, or Great Plains whorled milkweed. The stems, which are often

[1] In conformity with the cooperative arrangement between the Bureau of Plant Industry and the Bureau of Animal Industry in regard to investigations of poisonous plants, the material on which this paper is based was collected by W. W. Eggleston, Bureau of Plant Industry, and the description of *Asclepias pumila* and that of *A. verticillata var.* geyeri, on page 10, were prepared by him. Mr. Eggleston has made a detailed study of the systematic position and distribution of these plants, which it is expected will be published later.

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branching, are 3 to 12 inches high, tufted, and puberulent. The main root is horizontal, branching, and produces adventitious buds.

Figure 2 of Plate I shows plants growing from adventitious buds on the root. The leaves, which are 1 to 2 inches long, are sessile, numerous, crowded, and irregularly alternate to verticillate, linear-foliform, revolute, and scabrous-puberulent. The flowers are in terminal branching umbels, few to many flowered, with short peduncles, and are scabrous-puberulent. The greenish-white corolla has oblong lobes and white oblong hoods, which are hastate-sagittate in back view and shorter than the horn. The follicles are erect, puberulent and 1½ to 3 inches long. The plant is found in adobe draws, in

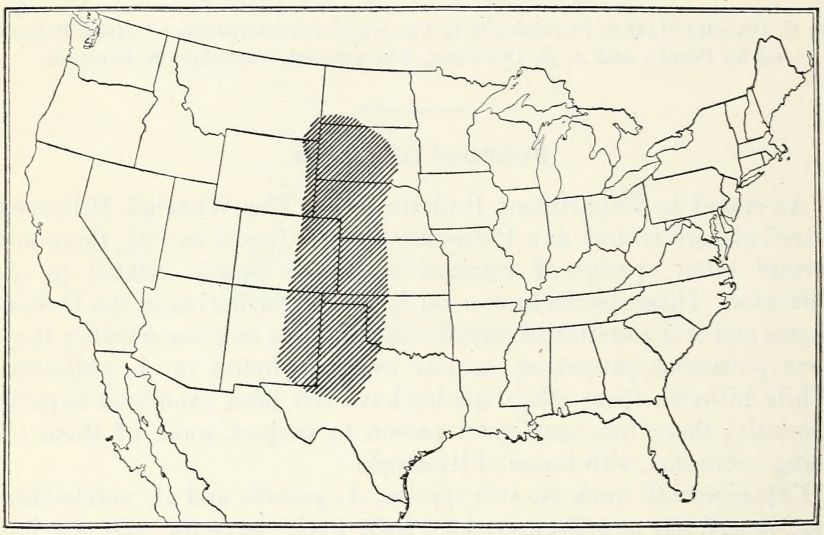

FIG. 1.—Distribution of *Asclepias pumila*.

dry plains, and in foothills from southeastern Montana and southwestern North Dakota to the Texas Panhandle and central New Mexico. It is most abundant on the plains of Colorado.

Text figure 1 shows the distribution of the plant. Although it has a root system and seeds similar to *Asclepias galioides*, it has not spread widely. It usually is scattered in small patches in draws.

The systematic position of *Asclepias pumila* is discussed in United States Department of Agriculture Bulletin 800, pages 5 and 6.

EXPERIMENTAL WORK WITH A. PUMILA.

All experimental work which was carried on in the summer of 1919 was with sheep, and the material in all cases was administered by the balling gun.

The plant material used was collected in Yuma County, Colo.—a part of it in the town of Wray. The material was dried, but in the experimental work was estimated as green plant, 72 per cent being allowed for loss of weight in drying.

The following table is a summarized account of the experiments, 22 in number:

TABLE 1.—*Summary of feeding experiments with Asclepias pumila (air-dried plant fed with balling gun).*

Animal.		Date of feeding.	Part of plant used.	Weight of plant (estimated as green plant) for 100 pounds of animal.	Remedy used.	Result.	Place and date of plant collection.
Designation.	Weight.						
	Pounds.	1919.		*Pounds.*			
Sheep 532..	98	July 23	Leaves and stems.	0.150	None.....	Not sick.....	Wray, Colo., July 5, 1919.
Sheep 514..	135	July 25	.....do.....	.197	.....do.....	.....do.....	Do.
Sheep 539..	99	July 26	.....do.....	.295	.....do.....	.....do.....	Do.
Sheep 547..	89.5	July 28	.....do.....	.402	.....do.....	.....do.....	Do.
Sheep 546..	100	July 29	.....do.....	.787	.....do.....	Symptoms....	Do.
Sheep 482..	122.5	Aug. 1	.....do.....	.787	.....do.....	.....do.....	Do.
Sheep 486..	135	Aug. 5	.....do.....	.827	.....do.....	Sick.....	Do.
Sheep 530..	95	Aug. 8	.....do.....	.866	.....do.....	Symptoms....	Do.
Sheep 536..	114	Aug. 11	.....do.....	.866	.....do.....	Somewhat sick	Do.
Sheep 539..	104	Aug. 15	.....do.....	.905	.....do.....	Symptoms....	Do.
Sheep 552..	94.5	Aug. 18	.....do.....	.984	.....do.....	Sick.....	Do.
Sheep 516..	81.5	Aug. 24	.....do.....	.984	.....do.....	.....do.....	Yuma County, Colo., Aug. 12, 1919.
Sheep 547..	95.5	Aug. 29	.....do.....	1.063	Eserin and pilocarpin.	.....do.....	Do.
Sheep 554..	104.5	Sept. 2	.....do.....	1.181	None.....	.....do.....	Do.
Sheep 546..	101.5	Sept. 6	.....do.....	1.339	.....do.....	.....do.....	Do.
Sheep 512..	124.5	Sept. 11	.....do.....	1.496	.....do.....	Symptoms....	Do.
Sheep 520..	102	Sept. 15	.....do.....	1.693	.....do.....	Sick.....	Do.
Sheep 539..	105.75	Sept. 17	.....do.....	.787	.....do.....	Symptoms....	Do.
Sheep 516..	80.75	Sept. 19	.....do.....	1.850	.....do.....	Sick.....	Do.
Sheep 542..	111.5	Sept. 23	.....do.....	1.968	.....do.....	.....do.....	Do.
Sheep 519..	85	Sept. 25	.....do.....	2.165	.....do.....	Died.....	Do.
Sheep 547..	99	Sept. 27	.....do.....	2.559	.....do.....	.....do.....	Do.

TYPICAL CASE OF SHEEP 547.

Sheep 547 was a ewe which had been used for other experimental work earlier in the season, but was in good condition when on July 28, 1919, she was selected for feeding with *Asclepias pumila*. At that time she weighed 84 pounds. At 3.10 p. m., 0.402 pound green weight of the plant per 100 pounds of animal was given by the balling gun. This produced no effect.

On August 29, at 6.04 p. m., the sheep was given, by the balling gun, 1.063 pounds of plant, green weight, per 100 pounds of animal. At this time she weighed 95.5 pounds. On August 30, at 7.25 a. m., the pulse was 112 and weak, the respiration 12, rather deep, with somewhat forcible expirations. She was humped up, with the head held high, and showed weakness in the hind legs. Later in the day

she staggered when walking, appearing "stiff behind." During this day and August 31 her condition remained much the same. She was depressed, held the head high much of the time, and staggered or wabbled when walking. On September 1 the uncertain movement in walking had largely disappeared, but she was rather inactive. On September 2 she had apparently entirely recovered. There was no elevation of temperature during this sickness.

This animal received several doses of eserin and pilocarpin, but apparently the remedy had no beneficial effect.

On September 27 another experimental feeding was made, the sheep at this time weighing 99 pounds. She received 2.559 pounds, green weight, per 100 pounds of animal, between 3.20 and 3.50 p. m. On September 28, at 7.40 a. m., she stood with head held high and nose extended, was somewhat bloated, and unsteady on her feet, this latter characteristic being most marked in the hind legs.

At 9.09 a. m. the pulse was weak, respiration irregular, and the animal staggered badly. This condition continued, the weakness and discomfort increasing. Plate II, figure 1, taken at 10.46 a. m., when she was somewhat salivated, illustrates the general condition. At 11.15 a. m. she was found down and unable to rise. She went into a spasm at 11.21, with the head drawn toward the breast. Another spasm followed at 11.35, the head being first drawn down and then thrown back in the position of opisthotonos.

The pulse at this time was rapid and weak and the respiration labored. Until about 6 p. m. there was an almost continuous series of spasms, the time between successive ones rarely being as much as 5 minutes. At noon running movements appeared in connection with the spasms. The spasms were very violent for the most part, opisthotonos being very marked and sometimes the head was struck upon the ground with great violence. Plates II and III show some of the attitudes assumed between 11.36 a. m. and 1.45 p. m.

About 6 p. m. the animal became comparatively quiet, and remained so until 8.50 p. m., when a series of continuous spasms commenced, which were terminated by death at 9.23 p. m.

Most of the time the pulse was rapid and weak. The respiration varied, sometimes being very rapid, and at others slower and labored. Text figure 2 shows the curve of temperature. It will be noted that there were three high periods, the maximum, 109.6 F., being at the time of death. The low period between 6 and 8 p. m. is correlated with a time of comparative quiet, but this is not true of the 3 o'clock low, for the spasms were practically continuous during the afternoon. The immediate cause of death was respiratory paralysis.

The autopsy was made immediately. There was clotted blood in the trachea and bronchi, and the lungs were congested. The stom-

achs appeared normal. There was some gas in the jejunum and ileum, and congestion in the posterior part of the ileum. The liver was pale and blotched, and the gall bladder was distended with gas. Tapeworms were present in the bile ducts and in the pancreatic duct. There were hemorrhagic spots on the surface of the thymus. The brain and spinal cord appeared normal.

The results of microscopic examination of the tissues are given on pages 7 to 10.

SYMPTOMS.

The most prominent symptom in all the cases of poisoning was a weakness of the hind quarters of the animals, which resulted in a staggering gait. There was in most of the cases depression and in

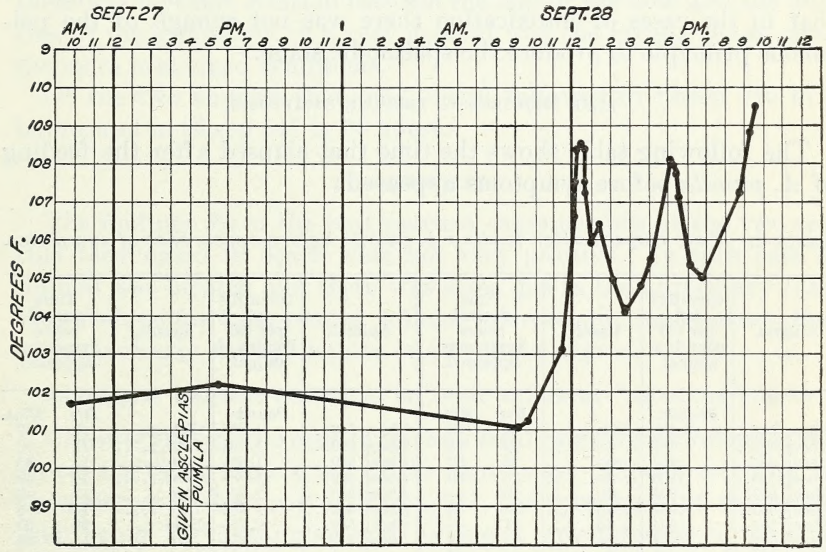

FIG. 2.—Temperature curve of Sheep 547.

some evident trembling, but the staggering was universally present and was particularly noticeable. This was not due in most cases to extreme weakness, for the animals could get about quite readily, but appeared in a gait which reminded one very much of a drunken man. This symptom of staggering was one which in some cases continued for several days. The pulse generally was weak and rapid, and the animals which were quite sick frequently accompanied the expirations with a grunt or a groan. In the cases which recovered there was no bloating, salivation, or spasm. It was quite noticeable in many of the cases that the animals when standing held the head high and the nose extended forward in a very characteristic fashion. In the animals which were fatally poisoned, in addition to the symptoms already described, there was some bloating and salivation, and

they exhibited violent spasms, accompanied with running movements. The temperature in the two fatal cases, Sheep 519 and 547, ran for a period very high, reaching a maximum of 107° F. in Sheep 519 and 109.6° F. in Sheep 547. In the spasms the latter animal threw itself at times in the opisthotonic position, and occasionally drew its head toward the thorax with a spasmodic motion.

In comparing these symptoms with those shown by *Asclepias galioides* there is nearly a complete resemblance. The symptoms exhibited in the fatal case of one could not be distinguished from those seen in the other. In the cases of intoxication with recovery, no spasms appeared, and in this respect *A. pumila* differs from *A. galioides*. This, however, may be explained by the fact that *A. pumila* is much less toxic than *A. galioides*, and it may be supposed that in the cases of intoxication there was not enough of the poisonous principle to produce the spasmodic stage.

TIME REQUIRED TO PRODUCE SYMPTOMS.

The following table shows the time that elapsed after the feeding of *A. pumila* before symptoms appeared:

TABLE 2.—*Time elapsed after feeding A. pumila before appearance of symptoms.*

Animal.	Quantity fed per 100 pounds of animal.	Result.	Time elapsed before symptoms appeared.		Animal.	Quantity fed per 100 pounds of animal.	Result.	Time elapsed before symptoms appeared.	
	Pounds.		*Hrs.*	*Mins.*		*Pounds.*		*Hrs.*	*Mins.*
Sheep 546..	0.787	Sick.....	13	40	Sheep 546...	1.339	Sick.....	13	40
Sheep 482..	.787	...do.....	30	15	Sheep 512...	1.496	...do.....	13	10
Sheep 486..	.827	...do.....	12	37	Sheep 520...	1.693	...do.....	13	46
Sheep 536..	.866	...do.....	16	50	Sheep 539...	0.787	...do.....	15	50
Sheep 539..	.905	...do.....	16	—	Sheep 516...	1.85	...do.....	17	40
Sheep 552..	.984	...do.....	15	45	Sheep 542...	1.968	...do.....	13	8
Sheep 516..	.984	...do.....	21	—	Sheep 519...	2.165	Died.....	20	20
Sheep 547..	1.063	...do.....	13	8	Sheep 547...	2.559	...do.....	15	50
Sheep 554..	1.181	...do.....	14	13					

The average time of all cases shown in the table was 16 hours 17 minutes.

CONTINUATION OF SYMPTOMS.

It was noticed in the experimental cases of poisoning with *A. pumila* that the symptoms in some cases continued for a long period of time. The following table shows these facts. This table was prepared by taking the time between the appearance of symptoms and the last time when symptoms were noted. The actual periods were probably somewhat greater than those in the table, for in most cases the first symptoms were noted in the morning, and the animals may have been sick earlier. It is probable, too, that the symptoms extended somewhat beyond the time the table would indicate.

TABLE 3.—*A. pumila—Duration of sickness in cases of recovery.*

Designation of animal.	Duration of symptoms.	Designation of animal.	Duration of symptoms.
Sheep 546	1 day.	Sheep 554	2 days 8 hours.
Sheep 482	1 day.	Sheep 546	3 days 9½ hours.
Sheep 486	2 days 2½ hours.	Sheep 512	2 days 4½ hours.
Sheep 536	2 days 4 hours.	Sheep 520	1 day.
Sheep 539	7½ hours.	Sheep 539	1 day 8 hours.
Sheep 552	1 day 1 hour.	Sheep 516	4 days.
Sheep 516	1 day 17 hours.	Sheep 542	5 days.
Sheep 547	2 days 4½ hours.		

It will be noticed that the symptoms continued from a minimum of 7½ hours to a maximum of 5 days. With the exception of Sheep 539 the dosage was gradually increased in the order of the table. While there was no exact relation between the size of the dose and the duration of the symptoms, in a very general way the greater doses caused the more prolonged symptoms.

Of the two animals that died, death followed in Sheep 519 in 32 hours, and in Sheep 547 in 38 hours.

AUTOPSIES.

The findings from the post-mortem examinations of the two cases that terminated in death were not very positive. In each case the animal was bloated and there was some gas in the alimentary canal. However, so far as appeared without microscopic examination, there were no clearly marked lesions in any of the organs.

MICROSCOPIC CHANGES IN TISSUES OF SHEEP KILLED BY "ASCLEPIAS PUMILA."

Liver.—The hepatic cells in the two fatal cases were swollen so as to crowd the blood largely out of the capillaries. Cloudy swelling was pronounced in the liver of Sheep 547, the cytoplasm of the hepatic cells being very granular and having a ground-glass appearance, which made it difficult to make out fine details. This condition was not so well advanced in Sheep 519. The blood in many veins contained much hemosiderin pigment, areas of granular material, pieces of degenerated hepatic cells, and sometimes portions of epithelium from the walls of the veins. Some of the veins were engorged, others not. The bile ducts were often catarrhal. The changes in the hepatic cells in both animals, especially in Sheep 547, were more pronounced than in the *A. galioides* cases.

Kidneys.—The changes were practically like those found in the *A. galioides* cases, consisting of areas of congestion and edema and a swollen and somewhat degenerated condition of the epithelium, particularly in the convoluted tubules. In many tubules the lumina were practically filled by the swollen cells. Other cells were degenerated and partly disintegrated. Most nuclei stained well; a few stained

very faintly, while others were wrinkled. In the congested areas there were deposits of hemosiderin pigment, much of it being in tubule epithelial cells. Apparently pronounced hemolysis occurred.

Heart.—This tissue was mildly congested in some areas in Sheep 547, and a few minute hemorrhages occurred. In both animals the cross-striated appearance was less pronounced than usual, especially in areas where the cytoplasm was more granular than normal. This was less marked than that found in some of the *A. galioides* cases, but was not materially different and probably was the result of excessive activity of the cardiac muscle.

Lungs.—The sections of the lungs of Sheep 547 showed congestion; those of Sheep 519 did not. In both cases, however, hemosiderin pigment was present and thrombi were found in the arteries. While these thrombi differed somewhat in detail their origin may have been and probably was the same. The fact that they were found in arteries indicates that they were embolic in nature and possibly originated in the liver.

Thyroid.—The thyroid from each animal appeared to be normal except for a possible slight increase in connective tissue in Sheep 540, which had no connection with the *A. pumila* poisoning. In the *A. galioides* cases the thyroid tissue was congested.

Thymus.—The thymus from Sheep 547 was the only one examined. It was severely congested and was hemorrhagic as well as edematous. The medullary portion of the lobules was especially full of blood. No changes of importance were noted in the lymphoid cells, though in places large cells with finely granular cytoplasm, apparently phagocytic in nature, were present.

Nervous system.—The pronounced congestion noted in various parts of the nervous system in the *A. galioides* cases was absent in both the sheep poisoned by *A. pumila*, though all portions examined were somewhat edematous. In the lumbar cord of each case, and in the cerebrum and the cerebellum of Sheep 519, a small amount of diapedesis of erythrocytes had occurred. The nerve cells of the medulla and spinal cord and the Purkinje cells of the cerebellum in both cases had undergone marked changes. The Purkinje cells of sheep poisoned with *A. galioides* were found to show marked, or in some cases, extreme fatigue effects. Changes in other nerve cells were apparently fatigue effects.

Thrombi were found in the meninges and sometimes in the nervous tissue. Some of these contained fibrin, others appeared hyalin.

Alimentary canal.—The only portion showing changes which may be considered due to the *A. pumila* was in the ileum and suggested the presence of an irritant. The ileum of Sheep 547 was mildly congested, and hemorrhages had occurred. In the mucosa was an abnormal number of mononuclear leucocytes. A similar invasion, but

FIG. 1.—ASCLEPIAS PUMILA.

FIG. 2.—ASCLEPIAS PUMILA, SHOWING PLANTS GROWING FROM ADVENTITIOUS BUDS ON THE HORIZONTAL ROOT.

FIG. 1.—SHEEP 547, AT 10.46 P. M., SEPTEMBER 28.

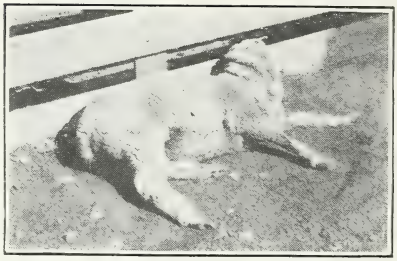

FIG. 2.—SHEEP 547, AT 11.36 A. M., SEPTEMBER 28.

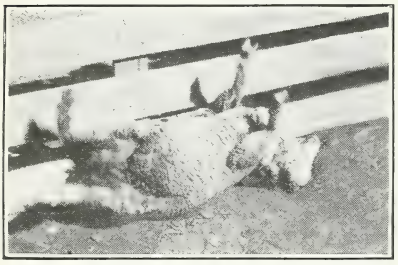

FIG. 3.—SHEEP 547, AT 11.39 A. M., SEPTEMBER 28.

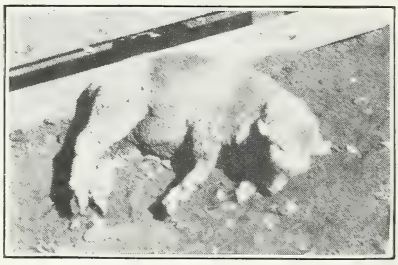

FIG. 4.—SHEEP 547, AT 11.43 A. M., SEPTEMBER 28.

FIG. 5.—SHEEP 547, AT 11.51 A. M., SEPTEMBER 28.

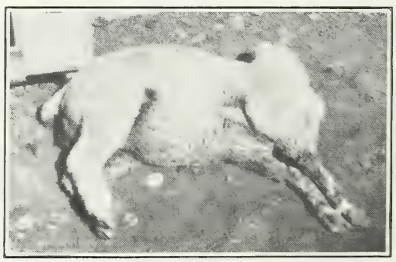

FIG. 6.—SHEEP 547, AT 11.55 A. M., SEPTEMBER 28.

FIG. 1.—SHEEP 547, AT 12.03 P. M., SEPTEMBER 28.

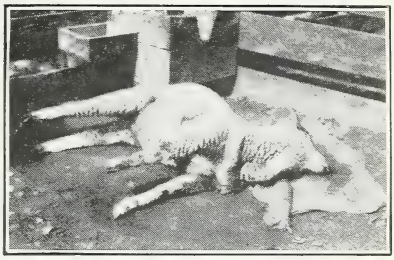

FIG. 2.—SHEEP 547, AT 12.06 P. M., SEPTEMBER 28.

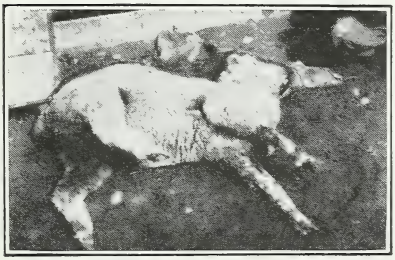

FIG. 3.—SHEEP 547, AT 12.09 P. M., SEPTEMBER 28.

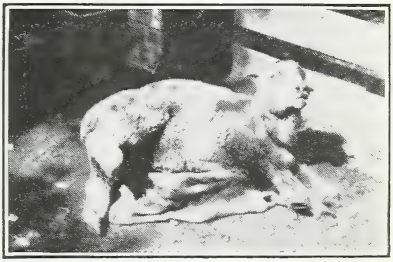

FIG. 4.—SHEEP 547, AT 1.01 P. M., SEPTEMBER 28.

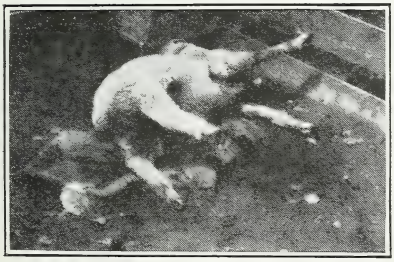

FIG. 5.—SHEEP 547, AT 1.09 P. M., SEPTEMBER 28.

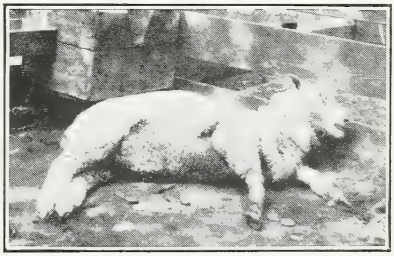

FIG. 6.—SHEEP 547, AT 1.45 P. M., SEPTEMBER 28.

of polymorphonuclear leucocytes, occurred in the mucosa of the ileum of Sheep 519. In some blood vessels thrombuslike areas occurred.

Spleen.—This organ was not very abnormal, though the presence of considerable hemosiderin pigment indicated a possible congestion which had subsided. The edematous condition of the Malpighian corpuscles in the spleen of Sheep 547 indicated a possible congestion.

While there was a marked similarity in the tissue changes to those in animals poisoned by *A. galioides*, there were certain slight differences, mainly of degree. On the whole the findings in the two sheep examined agreed very well.

TOXIC AND LETHAL DOSAGE.

The following table shows the dosage, estimated as green plant, of *A. pumila*, which resulted in sickness or death of the sheep.

TABLE 4.—*Dosages of A. pumila resulting in sickness or death.*

Animal.	Quantity per 100 pounds of animal.	Result.	Animal.	Quantity per 100 pounds of animal.	Result.	Animal.	Quantity per 100 pounds of animal.	Result.
	Pounds.			*Pounds.*			*Pounds.*	
Sheep 546...	0.787	Sick.	Sheep 516...	0.984	Sick.	Sheep 539...	0.787	Sick.
Sheep 482...	.787	Do.	Sheep 547...	1.063	Do.	Sheep 516...	1.85	Do.
Sheep 486...	.827	Do.	Sheep 554...	1.181	Do.	Sheep 542...	1.968	Do.
Sheep 536...	.866	Do.	Sheep 546...	1.339	Do.	Sheep 519...	2.165	Died.
Sheep 539...	.905	Do.	Sheep 512...	1.496	Do.	Sheep 547...	2.559	Do.
Sheep 552...	.984	Do.	Sheep 520...	1.693	Do.			

It will be noticed that the smallest quantity which produced intoxication was 0.787 pound per 100 pounds of animal. As shown in Table 1, the largest quantity fed without effect was 0.866 pound, to Sheep 530. In this case, however, there were possible symptoms. The smallest dose that produced death was 2.165 pounds per 100 pounds of animal. It may be recalled that in all the *A. pumila* cases the whole plant was used. There are no data to determine the comparative toxicity of different parts of the plant.

With *A. galioides* the smallest quantity of the whole plant that produced symptoms was 0.22 pound, and this dosage resulted in death. In comparing the two plants it is evident that *A. galioides* is nearly 3.6 times as toxic as *A. pumila.*

While, in the experiments with *A. galioides*, there was practically no difference between the toxic and lethal doses, in *A. pumila* it required nearly three times the toxic dose to produce death. As compared with *A. galioides* the lethal dose of *A. pumila* was 9.84 times as great. Because of the small number of cases which were compared, these figures must not be considered as exact, but they give a general idea of the relative toxicity of the two plants.

EXPERIMENTAL WORK WITH A. VERTICILLATA VAR. GEYERI.

A. verticillata, the whorled milkweed of the eastern part of the United States, is distributed throughout the Atlantic Plains and the Mississippi Valley. It differs materially from *A. galioides*, *A. pumila*, and *A. mexicana* in that it has long, fibrous roots and smooth pods.

A. verticillata var. *geyeri* can be distinguished from the typical form by its numerous adventitious buds on the fibrous roots. These slender, fibrous budded roots are often long and horizontal and thus simulate the single strong horizontal roots of *A. galioides*, *A. pumila*, and *A. mexicana*.

The material used in these experiments was collected at Missouri Valley, Iowa, on June 29, 1919.

Thirteen feedings of this plant were made to sheep by the balling gun, resulting in two animals becoming sick and one other very sick. Three feedings with hay were made to a horse, with no result.

The following table summarizes the experiments:

TABLE 5.—*Summary of feeding experiments with Asclepias verticillata var. geyeri (collected at Missouri Valley, Iowa, and air dried).*

Animal.		Date of feeding.	Method of feeding.	Part of plant used.	Weight of plant (estimated as green plant) for 100 pounds of animal.	Remedy used.	Result.
Designation.	Weight.						
	Pounds.	1919.			*Pounds.*		
Sheep 523 ..	82	July 14	Balling gun...	Leaves and stems.....	0.140	None....	Not sick.
Sheep 526 ..	90.5	July 15	.....do.....	.....do.....	.184	.....do...	Do.
Sheep 527 ..	82	July 16	.....do.....	.....do.....	.276	.....do...	Do.
Sheep 544 ..	95.5	July 17	.....do.....	.....do.....	.368	.....do...	Do.
Sheep 556 ..	98.5	July 18	.....do.....	.....do.....	.735	.....do...	Do.
Sheep 548 ..	103	July 19	.....do.....	.....do.....	1.102	.....do...	Do.
Sheep 540 ..	97	July 20	.....do.....	.....do.....	1.470	.....do...	Do.
Sheep 473 ..	114.5	July 21	.....do.....	.....do.....	2.205	.....do...	Very sick.
Sheep 556 ..	106	Aug. 12	.....do.....	.....do.....	2.021	.....do...	Not sick.
Sheep 546 ..	89.25	Aug. 22	.....do.....	.....do.....	2.113	.....do...	Do.
Sheep 552 ..	97	Sept. 20	.....do.....	Leaves and stems with large proportion of stems.	2.168	.....do...	Do.
Sheep 482 ..	129	Sept. 23	.....do.....	Leaves.....	1.286	.....do...	Sick.
Sheep 523 ..	92	Sept. 25	.....do.....	.....do.....	1.470	.....do...	Do.
Horse 126 ..	995	July 15-16	Fed with hay.	Leaves and stems.....	.072	.....do...	Not sick.
Horse 126 ..	995	July 17	.....do.....	.....do.....	.15	.....do...	Do.
Horse 126 ..	995	July 18-21	.....do.....	.....do.....	.133	.....do...	Do.

TYPICAL CASE OF SHEEP 473.

Sheep 473 was a wether weighing 114.5 pounds at the time of the experiment. On July 21, 1919, between 4.05 and 4.37 p. m., it received by the balling gun, per 100 pounds of animal, 2.205 pounds of the plant, estimated as green plant. At 6.40 a. m., July 22, the pulse was 152, weak, but regular, and the respiration was deep. It seemed weak in the hind legs and staggered as it walked.

At 7.23 a. m. it was down, throwing itself about spasmodically. The pupils were dilated and the animal was somewhat bloated. Opisthotonos was pronounced. The temperature at 6.40 a. m. was 101° F., and at 7.33 a. m. 103.4° F. At 8.02 a. m. running movements of the legs commenced. During most of the day and throughout the night following the condition of the animal did not change in any marked degree. It had mild spasms, accompanied by convulsive movements of the head and jaws. At times there was distinct trembling. Much of the time there was a good deal of bloat. Running movements occurred at times. The pulse was weak and the temperature at 2.10 p. m., and at 10.15 was as high as 105° F. The general condition was much like a mild case of *Asclepias galioides* poisoning. At no time were the spasms of a violent character; generally speaking, there was some correlation between the bloating and the spasmodic movements.

During the forenoon of July 23 it was more quiet than on the preceding day, but it still groaned, had a weak pulse, and at 9.35 a. m. the temperature was 104° F. At noon, while the pulse was still rapid, it was strong. During the afternoon the sheep drank water and became more quiet, though it was still bloated.

During the forenoon of July 24 the pulse varied, being weak at times, but on the whole showed improvement. The sheep attempted to eat at 9.35 a. m. It remained down until 2.30 p. m., when it got on its feet.

On July 25, while still much depressed, the sheep was improving steadily and both ate and drank. The temperature was normal, but the pulse, while strong, was still rapid. By the night of July 26 the sheep's condition was normal. It was kept under observation on July 27, and was turned into pasture on July 28.

SYMPTOMS.

Of the three sheep poisoned by *Asclepias verticillata* var. *geyeri*, two, Sheep 482 and Sheep 523, were sick, and one, Sheep 473, was very sick. Both Sheep 482 and Sheep 523 staggered and showed general weakness, which, in the case of Sheep 482, was more pronounced in the hind legs. In this animal the respiration was labored and in Sheep 523 a weak pulse was noted.

In the case of Sheep 473 all the typical symptoms of *Asclepias galioides* were noted, including weakness, especially marked in the hind legs, staggering, weak and rapid pulse, labored respiration (the expirations accompanied with groans), dilated pupils, elevated temperature, bloating, spasms with opisthotonos, and running movements. Spasmodic movements of the mandibles in a chewing movement were very noticeable.

TIME REQUIRED TO PRODUCE SYMPTOMS.

The following table shows the time that elapsed between the giving of the plant and the appearance of symptoms:

TABLE 6.—*Time elapsed after feeding A. verticillata var. geyeri before appearance of symptoms.*

Animal.	Quantity fed per 100 pounds of animal.	Result.	Time elapsed before symptoms appeared.	
	Pounds.		*Hrs.*	*Mins*
Sheep 473	2.205	Very sick	14	10
Sheep 482	1.286	Sick	15	35
Sheep 523	1.47	....do	20	35

The average time before symptoms appeared was 16 hours 47 minutes. As noted on page 6, this time, in the case of *Asclepias pumila*, was 16 hours and 17 minutes. In Bulletin 800, United States Department of Agriculture, page 34, it was shown that in the *Asclepias galioides* cases the average elapsed time was 14.1 hours. It is evident that in respect to the time elapsing between the feeding and the development of symptoms, the three species are practically alike.

CONTINUATION OF SYMPTOMS.

As in *A. pumila* cases, the symptoms persisted for a considerable length of time after their first appearance.

In Sheep 473, symptoms continued 4 days.
In Sheep 482, symptoms continued 2 days.
In Sheep 523, symptoms continued 1 day.

Sheep 473 was the only animal seriously affected, and the symptoms continued much longer than in the others.

COMPARISON OF DURATION OF SYMPTOMS IN A. PUMILA, A. VERTICILLATA VAR. GEYERI, AND A. GALIOIDES.

The following statement shows the time during which symptoms persisted in the *A. galioides* cases:

Horse 126, symptoms continued 6 days.
Cattle 750, symptoms continued 1⅓ days.
Sheep 478, symptoms continued 6 hours.
Sheep 506, symptoms continued 3 hours.
Sheep 534, symptoms continued 1 hour.
Sheep 542, symptoms continued 4 hours.
Sheep 372, symptoms continued 11 hours.
Sheep 522, symptoms continued (September 11) 3½ hours.
Sheep 522, symptoms continued (September 22) 4 hours.

For comparative purposes the horse and cow may be disregarded. In fact, the horse never completely recovered, although the immediate symptoms of the sickness disappeared.

Of the sheep, 534 was only slightly sick, and 372 and 522, in both experiments, showed only symptoms. The average time of the sheep cases was between $4\frac{1}{2}$ and $4\frac{3}{4}$ hours, with a minimum of 1 hour and a maximum of 11 hours. The symptoms persisted longer in the more pronounced cases.

It was shown on page 7 that the *A. pumila* cases continued from $7\frac{1}{2}$ hours to 5 days, and on page 7 that *A. verticillata* var. *geyeri* cases varied from 1 to 4 days, averaging 2 days and 8 hours.

If sheep poisoned by *A. galioides* recovered they were sick only a few hours, while with both *A. pumila* and *A. verticillata* var. *geyeri* the symptoms continued for a prolonged period.

Inasmuch as in all the whorled-milkweed cases the symptoms continued longer in the more pronounced cases, and as *A. galioides* is vastly the most toxic of the three species, one would expect the *A. galioides* cases to continue the longest. This unexpected result is a matter of a good deal of interest, and there is reason to think that it will be explained by the detailed chemical study of these plants, which is now in progress.

TOXIC DOSE.

The leaves and stems of the plant (*A. verticillata* var. *geyeri*) were given by the balling gun to 10 sheep. As *Asclepias galioides* had been found to be extremely toxic, the experiments were commenced with small doses, which were gradually increased until results were obtained. No effect was produced until Sheep 473 became very sick on 2.205 pounds per hundredweight of animal. As Sheep 556 was not affected by 2.021 pounds, nor Sheep 546 by 2.113 pounds, it is a fair inference that 2.205 pounds is very close to the toxic dose. The smallest toxic dose of *Asclepias galioides* is 0.22 pound, while the smallest toxic dose of *Asclepias pumila* is 0.787 pound. *Asclepias verticillata* var. *geyeri*, then, is about one-third as toxic as *A. pumila* and about one-tenth as toxic as *A. galioides* when leaves and stems are fed.

In feeding the leaves of the plant by the balling gun the smallest dose was 1.286 pounds. The smallest toxic dose of *A. galioides* leaves fed in the same way was 0.138 pound, so that in this case the *A. galioides* was about nine times as toxic as the *A. verticillata* var. *geyeri*.

COMPARATIVE TOXICITY OF STEMS AND LEAVES.

It may be noted that, as shown in the preceding paragraph, when leaves and stems are fed together the toxic dose is 2.2 pounds, while with leaves alone it is 1.378 pounds. This difference, of course, is due to the greater toxicity of the leaves. This is a matter of a great deal of interest, for extended experiments on *A. galioides* carried on since the publication of Bulletin 800 have conclusively shown a

similar relation in this plant. It follows that the losses by the whorled milkweeds are for the most part caused by eating the leaves rather than the stems.

SUMMARY.

Closely allied to the extremely poisonous whorled milkweed *Asclepias galioides* are two species, *A. pumila*, growing in the plains region east of the Rocky Mountains, and *A. verticillata* var. *geyeri*, growing in the eastern United States.

These two species produce in animals symptoms and pathological results closely resembling those produced by *A. galioides*.

As compared with *A. galioides*, *A. pumila* is about one-third as toxic and the Missouri Valley species (*A. verticillata* var. *geyeri*) about one-tenth as toxic.

As stock-poisoning plants these last two species have no history, but there is reason to think that if grazing animals were closely confined to them injurious results would follow.

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